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DEPARTMENT OF MINES

Mineral Resources Circular No. 6

Phosphate in Ontario

By
D. F. HEWITT

1967

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PHOSPHATE IN ONTARIO

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Abstract

This mineral resources circular briefly describes 77 deposits of apatite in Ontario. The types of apatite deposits are described. There has been recent interest in apatite deposits associated with alkaline-carbonatite complexes and some large reserves of apatite are reported. Production of apatite in Ontario has amounted to 35,627 tons valued at $394,519 between 1892 and 1951.

Phosphate in Ontario

By

D. F. Hewitt[1]

Introduction

The phosphate mining industry began in Ontario about 1870, and flourished until 1892, when competition from cheaper Florida phosphate rock reduced the price. There has been intermittent phosphate production from 1892 until 1951 when mining ceased. The cessation of phosphate production has been largely due to the competition of cheap sources of phosphate rock in Florida, Tennessee and Montana. Most of the Ontario deposits operated during these years have been small and irregular in shape and size. The vein deposits are pockety.

The recent discovery of alkaline-carbonatite complexes with large tonnages of apatite and magnetite has revived interest in the Ontario phosphate industry and renewed production of phosphate in Ontario in the future seems likely. In 1964, 1,406,424 short tons of phosphate rock valued at $11,719,401 were imported into Canada, mainly from Montana and Florida. The phosphate rock was worth between $7.00 and $8.00 a ton.

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Uses and Specifications of Phosphate

The principal use of phosphate is in the phosphate fertilizer industry. J.E. Reeves (1964) has given the following summary of developments in the phosphate fertilizer field:

"In early 1964 The Consolidated Mining and Smelting Company of Canada Limited completed a 100,000 ton-a-year extension of its ammonium phosphate plant at Kimberley, British Columbia, and its subsidiary, Montana Phosphate Products Company, completed the development of the Douglas Creek mine and construction of a 300,000 ton-a-year phosphate rock concentrator near Maxwell in southwestern Montana. In addition, it began construction of a 100,000 ton-a-year ammonium phosphate plant at Regina, Saskatchewan, and an extension of the phosphoric acid plant at Kimberley to feed the Regina plant - both to be completed in 1965."

"At Fort Saskatchewan, Alberta, Sherritt Gordon Mines, Limited, started construction of a plant capable of producing 125,000 tons of ammonium phosphate a year. Completion is scheduled for the latter part of 1965. Phosphate rock will be imported from Florida via Vancouver."

Late in 1964 Border Fertilizer Limited began producing ammonium phosphate at Transcona, Manitoba, from a new plant with a capacity of 80,000 tons a year. Phosphate rock is imported from Wyoming."

"During the year construction was begun on an expansion of the ammonium phosphate plant of Northwest Nitro-Chemicals Limited at Medicine Hat, Alberta, and on a new fertilizer plant at Calgary, Alberta, to be operated by Western Co-operative Fertilizers Limited. The latter plant is being financed by three large co-operatives - The Alberta Wheat Pool, The Saskatchewan Wheat Pool and Federated Co-operatives Limited - and will include in its production 520 tons of ammonium phosphate a day."

"Plans for several new phosphate fertilizer plants have been announced. Brunswick Fertilizer Corporation Limited, owned jointly by Brunswick Mining and Smelting Corporation and the British parent company of Electric Reduction Company of Canada Limited, Albright & Wilson Limited, will build a plant for the production of 680,000 tons of ammonium phosphate a year, mainly for export. The plant, which will be located near Belledune, north of Bathurst, New Brunswick, will consume byproduct sulphuric acid from the proposed nearby iron ore (pyrite) plant and imported phosphate rock. St. Lawrence Fertilizers Limited was incorporated to operate a wet-process phosphoric acid plant and related fertilizer plants at Valleyfield, Quebec, using byproduct sulphuric acid from the smelter of Canadian Electrolytic Zinc Limited and phosphate rock imported probably from Morocco. The acid plant will reportedly have a capacity of about 300 tons a day. Canadian Industries Limited will build a large fertilizer complex, including units for making phosphoric acid and ammonium phosphate, at Courtright, south of Sarnia, Ontario. J.R. Simplot Company will build a fertilizer complex at Winnipeg, including an ammonium phosphate plant with a capacity of 225,000 tons a year. It will import the necessary phosphoric acid from its expanded facilities in Pocatello, Idaho."

For the manufacture of fertilizer, phosphate rock should contain at least 68 percent bone phosphate of lime (B.P.L.) and may contain as high as 77 percent B.P.L. depending on the process. For electric furnace use, a lower B.P.L. content is acceptable but the rocks must have no excess calcium, a maximum of 3 percent Fe_2O_3 plus Al_2O_3, and be mostly coarser than 5 mesh (Reeves 1964, p. 483).

Phosphate is also used for the manufacture of phosphorous chemicals which are widely used in the manufacture of soaps

and detergents. Reeves (1964) states that the food-processing industry uses considerable amounts as a leavening agent in baking powders, cake mixes, etc. and in food preservatives. Phosphorous chemicals are also used in paints, plastic and paper manufacturing, pharmaceutical preparations and other products.

Prices

Prices for phosphate rock are quoted from Metals Week of July 17, 1967 in Table 1.

Table 1 Phosphate rock: Florida pebbles, washed, dry basis, unground bulk, long ton, f.o.b. vessel Tampa range:

66-68% B.P.L.	$ 7.70
70-72%	9.02
72-73%	9.30
74-75%	10.18
76-77%	11.28

Production

Annual Canadian production of phosphate from 1870 to 1919 is given by Spence (1920, p. 23), together with the average value per ton. The marked decrease in value per ton with the advent of Florida phosphate in 1893 is shown in Table 2.

Table 2 Annual Production of Phosphate from 1870 to 1919.

Year	Amount	Value	Average value per ton
	tons.	$	$
*1870..	1,200	13,600	11.33
*1871..	200	2,100	10.50
1872..)			
1873..)			
1874..- No Records			
1875..)			
1876..)			
**1877..	2,823	47,084	16.68
1878..	10,743	208,109	19.37
1879..	8,446	122,035	14.45
1880..	13,060	190,086	14.55
1881..	11,968	218,456	18.25
1882..	17,153	338,357	19.73
1883..	19,716	427,668	21.69
1884..	21,709	424,240	19.54
1885..	28,969	496,293	17.13
**1886..	20,495	304,338	14.85
1887..	23,690	319,815	13.50
1888..	22,485	242,285	10.77
1889..	30,988	316,662	10.21

1890..	31,753	361,045	11.37
1891..	23,588	241,603	10.24
1892..	11,932	157,424	13.19
1893..	7,890	61,962	7.85
1894..	6,861	41,166	6.00
1895..	1,822	9,565	5.25
1896..	570	3,420	6.00
1897..	908	3,984	4.39
1898..	733	3,665	5.00
1899..	3,000	18,000	6.00
1900..	1,415	7,105	5.02
1901..	1,033	6,280	6.07
1902..	856	4,953	5.79
1903..	1,329	8,214	6.18
1904..	817	4,590	5.62
1905..	1,300	8,425	6.48
1906..	850	6,375	7.50
1907..	824	6,018	7.30
1908..	1,596	14,794	9.26
1909..	998	8,054	8.07
1910..	1,478	12,578	8.51
1911..	621	5,206	8.38
1912..	164	1,640	10.00

1913..	385	3,643	9.46
1914..	954	7,275	7.62
1915..	217	2,502	11.53
1916..	203	2,514	12.38
1917..	149	1,486	10.00
1918..	140	1,200	8.57
1919..	24	331	13.80
Total..	338,055	4,686,145	

*Production solely from Ontario.
**From 1877 to 1886, figures represent exports only, no direct production returns having been furnished previous to the latter year. The "average value" figures are not to be regarded as representing current market prices, several grades of phosphate often being included in the returns.
From Spence (1920, p. 23).

Table 3. Ontario Production of Phosphate

Year	Tons	Value ($)
1870	1,200	13,600
1871	200	2,100
1878	824	12,278
1879	1,842	20,565
1880	1,387	14,422
1881	2,471	36,117
1882	568	6,338
1883	50	500

1884	763	8,890
1885	434	5,962
1886	1,000	15,735
1887	4,101	55,363
1888	2,089	22,506
1889	3,436	29,262
1890	4,581	51,065
1891	3,344	35,187
1892	1,701	22,460
1893	240	1,886
1898	101	505
1899	1,721	10,326
1900	145	1,015
1906	250	1,875
1907	416	2,608
1908	881	7,048
1909	272	1,904
1910	22	192
1911	20	240
1914	450	3,150
1915	17	102
1916	13	174
1917	20	256

1919	2	31
1922	59	476
1927	82	824
1935	70	60
1942	334	4,458
1943	401	4,113
1945	8	120
1950	106	712
1951	6	94
Total..	35,627	394,519

Types of Deposits

The phosphate deposits of Ontario are composed of the mineral apatite, (Ca, F, Cl) Ca_4 $(PO_4)_3$. The apatites of Ontario are fluor-apatite. There are four principal types of apatite deposit in Ontario:

(1) Silicated marble with disseminated apatite;

(2) Metamorphic pyroxenite with apatite;

(3) Hydrothermal vein deposits;

(4) Alkaline-carbonatite complexes.

(1) Silicated Marble with Disseminated Apatite:

The principal deposit of this type is the Campsall

occurrence in lot 3, concession II, Hinchinbrooke township, Frontenac county. Fine-grained apatite and magnetite is disseminated in medium-grained crystalline limestone. In places apatite makes up as much as 25 percent of the rock. It is likely that this fine-grained, evenly disseminated apatite is of sedimentary origin and has been metamorphosed with the crystalline limestone.

(2) Metamorphic Pyroxenite with Apatite:

Occurrence

The most common type of apatite deposit in Ontario is the metamorphic pyroxenite type which occurs in two principal areas of the Grenville geologic province of southeastern Ontario. There are a large number of apatite deposits south of Perth, mainly centred in North Burgess township, Lanark county. The second large group of apatite deposits occurs north of Kingston in Loughborough and Bedford townships, Frontenac county.

The metamorphic pyroxenite deposits occur in terranes of high grade metamorphic gneisses and granite gneisses associated with marble and paragneiss. The metamorphic pyroxenite is thought to be altered marble.

There are 3 varieties of metamorphic pyroxenite deposits:

The vein or fissure type, where the pyroxenite and apatite form a vein or fissure-filling in the country rock; the pocket type where the apatite is segregated in clusters or pockets in pyroxenite which pinches and swells; and thirdly the contact type where apatite occurs on the contact of pyroxenite and country rock or pegmatite.

Several varieties of metamorphic pyroxenite deposits are illustrated in the accompanying figures from de Schmid (1912). Figure 1 is the Freeburn mine in lot 3, concession VII, Loughborough township, Frontenac county. The pyroxenite dike cuts gneiss and carries vein-like leads of phlogopite, apatite and calcite.

Figure 2 is a mica deposit in lot 14, concession VIII, Loughborough township, Frontenac county. The mica and minor apatite occur in calcite veins in pyroxenite.

Figure 3 is a mica-apatite deposit in lot 14, concession VIII, Loughborough township, Frontenac county. A coarsely crystalline calcite vein carrying mica and apatite cuts pyroxenite and crystalline limestone. Some mica occurs along the vein contact in the crystalline limestone.

Figure 4 is the Amey mine in lot 13, concession VIII, Loughborough township, Frontenac county. The country rock is gneiss; the main ore bodies are calcite carrying mica and apatite. The calcite is enclosed in pyroxenite which in turn

is margined by augite syenite.

Figure 5 is a mica-apatite deposit in lot 9, concession V, North Burgess township, Lanark county. The country rock is gneiss cut by veins of metamorphic pyroxenite which carries irregular, branching, pockety leads of mica with minor apatite.

Figure 6 is a mica-apatite deposit in lot 3, concession VIII, North Burgess township, Lanark county. The mica-apatite vein occurs in metamorphic pyroxenite which is margined by a granitic rock. The banded complex cuts gneiss country rock.

Figure 7 is a mica deposit in lot 2, concession IV, South Sherbrooke township. This is a contact deposit with mica occurring in marble along the contact of metamorphic pyroxinite in branching form.

Figure 8 is a sectional view of Currie's typical mineral relationships in a mica-apatite deposit (Currie 1951, p. 774).

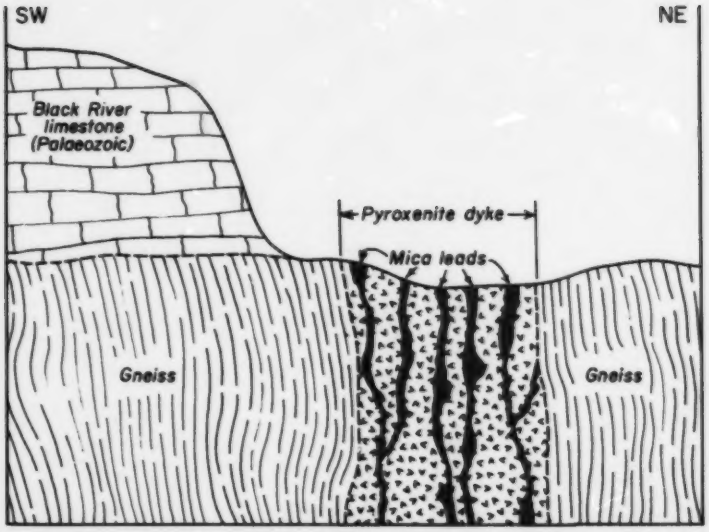

Figure 1 - Section through mica deposits at Freebern mine, lot 3, concession VII, township of Loughborough. (After de Schmid 1912.)

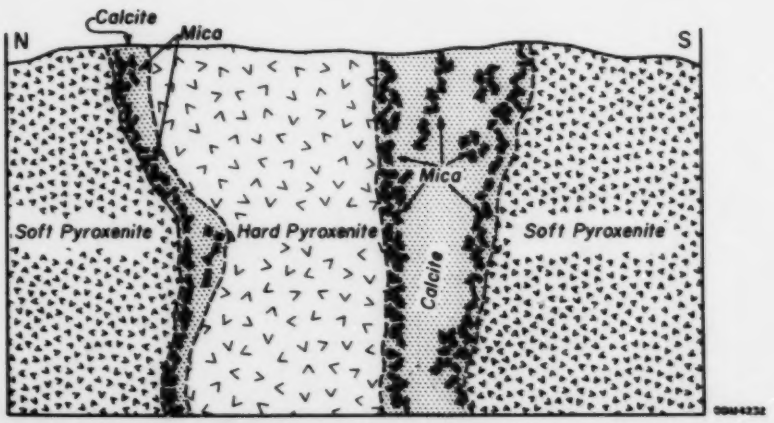

Figure 2 - Section through mica deposit, lot 14, concession VIII, township of Loughborough. (After de Schmid 1912).

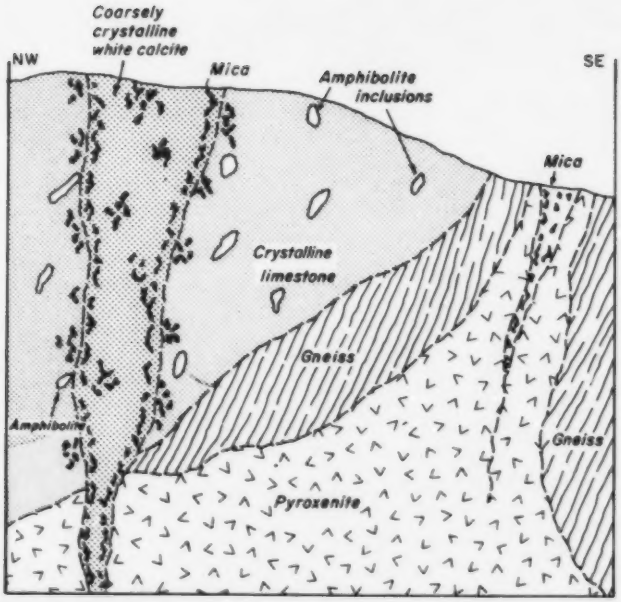

Figure 3 – Schematic section through mica deposits, lot 14, concession VIII, township of Loughborough. (After de Schmid 1912.)

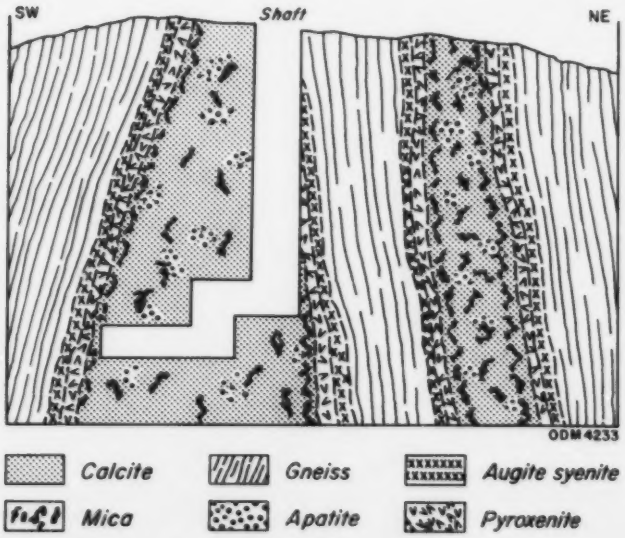

Figure 4 – Section through mica deposit at Amey mine, lot 13, concession VIII, township of Loughborough. (After de Schmid. 1912.)

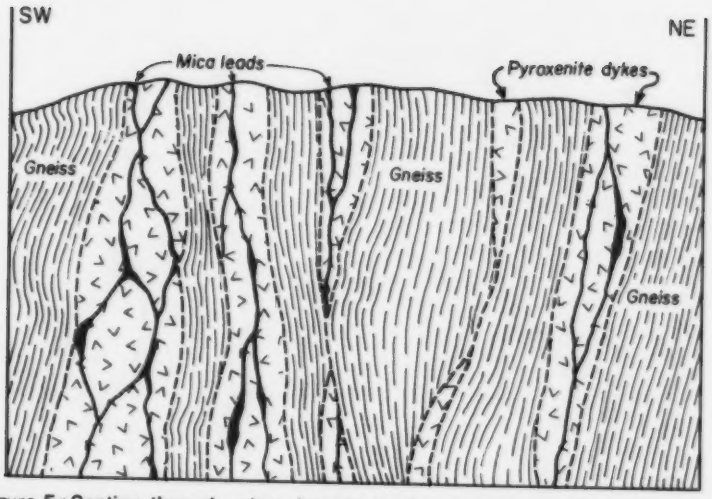

Figure 5-Section through mica deposit, lot 9, concession V, township of North Burgess, showing system of parallel pyroxenite dykes with mica leads. (After de Schmid 1912.)

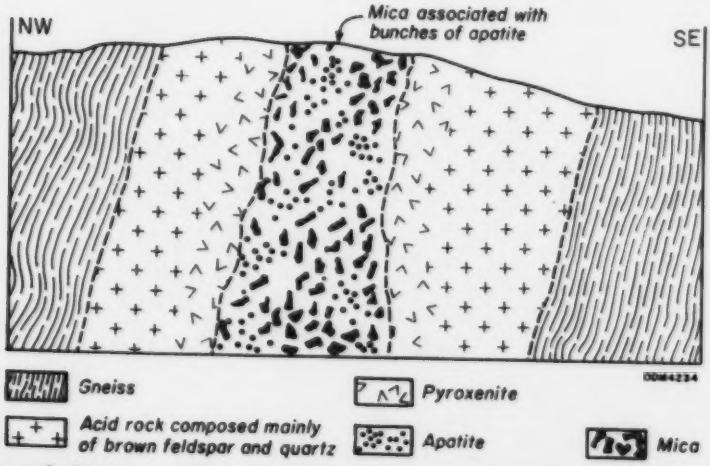

Figure 6-Section through mica deposits, lot 3, concession VIII, township of North Burgess. (After de Schmid 1912.)

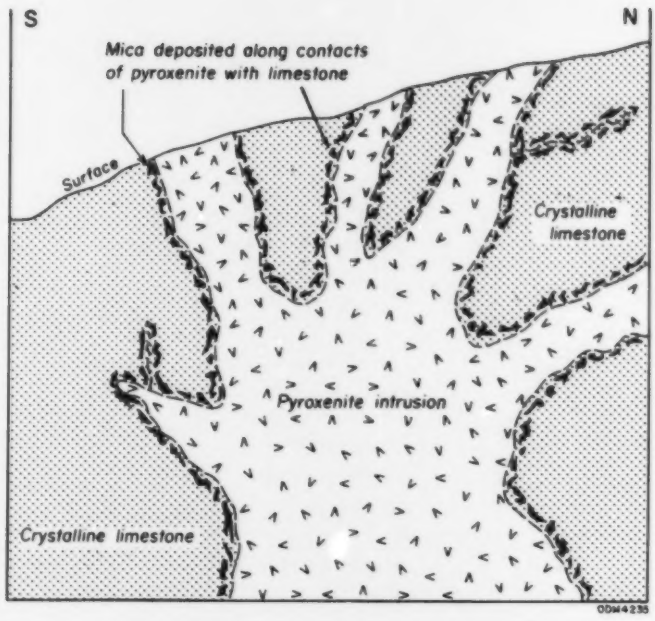

Figure 7- Schematic section through mica deposit, lot 2, concession IV, township of South Sherbrooke. (After de Schmid 1912)

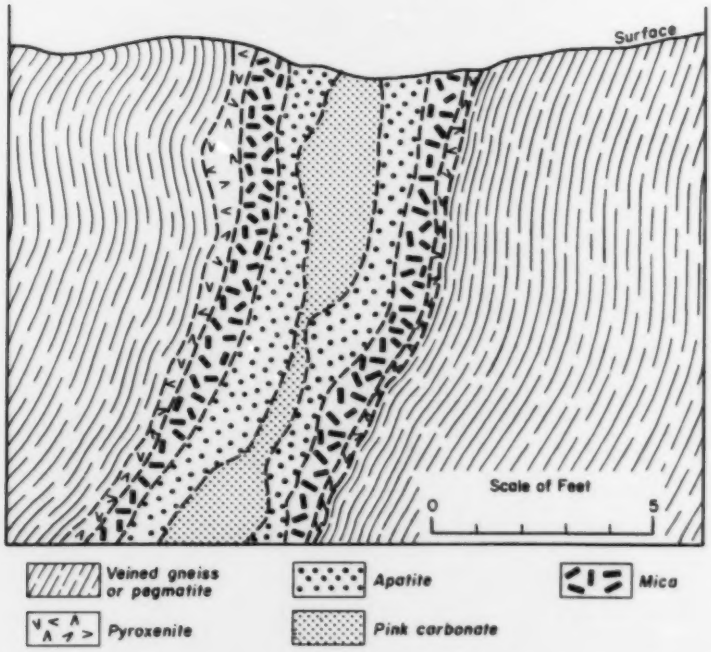

Figure 8- Sectional view of mineral relationships in a mica-apatite deposit. (After J. B. Currie.)

The zonal sequence of country rock-metamorphic pyroxenite - calcite with apatite and mica is noteworthy and characteristic of many of these deposits. Phlogopite and apatite are almost invariably associated in the metamorphic pyroxenite type of deposit, but occasionally apatite or mica will predominate to the exclusion of the other. The phlogopite-apatite deposits occur in veins, pockets or marginal to the metamorphic pyroxenite.

Mineralogy

The essential minerals present in the metamorphic pyroxenite type of deposit are pyroxene, phlogopite, calcite and apatite. Common accessory minerals are pyrite, pyrrhotite, scapolite and hornblende. Minor accessory minerals which may or may not be present are listed by Spence (1929, p. 46) as follows: Actinolite, albite, allanite, anhydrite, barite, chabazite, chalcopyrite, chlorite, datolite, epidote, faujasite, fluorite, galena, garnet, goethite, graphite, hematite, magnetite, microcline, molybdenite, natrolite, olivine, orthoclase, prehnite, quartz, rensselaerite, rutile, serpentine, specularite, sphalerite, spinel, steatite, titanite, tourmaline, tremolite, vesuvianite, wilsonite, zircon.

Origin of Metamorphic Pyroxenite Deposits

The origin of this type of apatite-mica deposit has been the subject of much controversy. The two principal hypotheses are (1) that the pyroxenite is the product of metamorphism of crystalline limestone and (2) that the pyroxenites are basic intrusives akin to basic pegmatites. A detailed summary of early views of the problem is given by de Schmid (1912, p. 250-272). He gives his later views in 1920 (Spence 1920, p. 122), and states that:

"the mica-apatite deposits possess the form of irregular, pockety masses enclosed in pyroxenite ..... The pyroxenites represent metamorphosed limestones which have been invaded, disrupted and engulfed, by immense batholithic masses of granite to which latter rock a gneissic character has been imparted by subsequent dynamic movements."

"The origin of the mica-apatite-calcite bodies is probably to be attributed to the agency of late pegmatitic phases of this granite and of the aqueous solutions accompanying the pegmatites. These solutions were charged with phosphoric acid, and the apatite is, therefore, to be considered of igneous origin, rather than to have been derived from the original limestones. The calcite probably represents calcium carbonate dissolved from the limestones by heated waters, and redeposited in cavities in the pyroxenites, while the mica is of contact metamorphic origin."

These views agree well with the writer's opinions on origin.

In discussing the origin of the deposits de Schmid (1912, p. 266) states that:

"R.A. Penrose (1888) regards the occasional, parallel

bands in some pyroxenites as probable joint planes, and mentions the frequent absence of any sharp contact between gneiss and pyroxenite, the border zone being a gradual transition from one to the other with the formation of a pyroxene gneiss."

de Schmid (1912, p. 270) states that:

"Penrose recognizes what seems actually to be the case in many deposits - namely, the gradual transition from pyroxenite to gneiss, and this type of the latter rock is probably the grey, sedimentary gneiss of Adams and Barlow and others."

In 1929 Spence had swung to favour the igneous hypothesis and Spence (1929, p. 40) states that:

"Various characteristics of the pyroxenites and mica-apatite bodies lend considerable support to the view that they are of igneous origin, and are basic intrusives, akin to pegmatites. Chief of these is the fact that the pyroxenite exhibits sharp, frozen contacts with the enclosing gneiss or limestone. The writer has observed no instance of a gradual transition of mica-bearing pyroxenite to country rock, as might be expected if the pyroxenite were a product of metamorphism."

K.K. Landes (1938, p. 359-388) also discusses the origin of the Quebec phlogopite-apatite deposits. He concluded that the theory of contact metamorphism is untenable because of crosscutting relationships of pyroxenite to country rock. The calcite is thought to be hydrothermal not residual. A granite pegmatite magma unusually rich in phosphorus became contaminated by dolomite. This contaminated magma moved upward into rock now exposed and crystallized. Pyroxenite was the earliest product followed by microcline and several minerals. Finally aqueous solutions from a deeper crystallizing

magma introduced a hydrothermal phase during which calcite, apatite, phlogopite and other minerals were deposited. Landes makes the following points: (1) The pyroxenite has crosscutting relations with the country rock; (2) Some of the minerals are characteristic of contact metamorphism of magnesian limestone. Such minerals as diopside, scapolite and phlogopite are formed where interaction has taken place between siliceous emanations and dolomitic country rock; (3) Magnesian limestone is scarce in the vicinity of the majority of mica-phosphate deposits; (4) The abundance of microcline pegmatite necessitates a source magma high in potash and not essentially a pyroxenitic magma.

J.B. Currie (1951, p. 765-778) has described the occurrence and relationships of some mica-apatite deposits in North Burgess township. He gives evidence that the pyroxenite in the mica-apatite deposits has originated through contact metamorphism of crystalline limestone by pegmatitic solutions. Pegmatitic solutions are thought to be responsible for the depositon of the mica and apatite. The calcite is considered to be of sedimentary origin.

The writer favours a contact metamorphic origin for the metamorphic pyroxenite which is frequently in close association with limy paragneiss and amphibolite. Hydrothermal solutions

associated with the intrusion and contact metamorphism of the crystalline limestones are responsible for depositing the phlogopite, apatite and other minerals. Mobility and injection of marble into associated country rocks explains the apparent intrusive relations of the metamorphic pyroxenite. Metamorphic pyroxenite deposits are a common type of deposit in the Bancroft area where molybdenite and uraninite deposits are found in metamorphic pyroxenite. Examples of uraninite deposits occurring in metamorphic pyroxenite are those at the McLean-Hogan property, Halo mine and Bicroft mine. The uraninite -bearing metamorphic pyroxenite at Bicroft mine was an old mica prospect.

(3) Hydrothermal Vein Deposits:

Hydrothermal vein deposits consisting predominantly of calcite with accessory purple fluorite, apatite and phlogopite, with or without uraninite and uranothorite, occur in the Wilberforce-Bancroft area of eastern Ontario. Examples of this type of deposits are Cardiff Uranium mine, Fission mine, the Nu-Age (Tripp) mine and several other occurrences in the area (Hewitt 1957, p. 56). Accessory minerals often include hornblende, pyroxene, magnetite, titanite,betafite and scapolite. The veins occur as lenticular, discontinuous, fissure fillings from a few inches to 12 feet wide and up to

300 feet long. None of the hydrothermal vein deposits has been a commercial source of apatite.

(4) Alkaline-Carbonatite Complexes:

The most promising new apatite deposits recently found in Ontario occur in association with alkaline-carbonatite plugs, a number of which have been found in Ontario. The best-known and most highly developed ore bodies are those of Multi-Minerals Limited in McNaught and Lackner townships, District of Sudbury, 7 miles northeast of Nemegos station. Diamond drilling has outlined several ore zones. Zones 3 and 4 are estimated to contain 37,000,000 tons grading 21.3 percent apatite, 13.7 percent magnetite and 0.198 percent columbium oxide. No. 6 zone is estimated to contain 5,024,250 tons to 500-foot depth, grading 69.6 percent magnetite, 21.9 percent apatite and 0.173 percent columbium oxide (Canadian Mines Handbook, 1966-1967, p. 219).

Several of the alkaline-carbonatite complexes are described by Parsons (1961). The Nemegos deposit has been described by Hodder (1961). Regarding the occurrence and origin of the magnetite-apatite bodies he states (Hodder 1961, p. 53),

"the magnetite-apatite bodies at Nemegos are pod-shaped and lie within the malignite. The walls of the bodies are vertical or dip steeply and the strike of the contacts and

foliation conforms roughly to that of the foliation in the malignite. Blocks of malignite are included within the orebodies and bear no evidence of alteration. Unaltered nepheline syenite is also present within magnetite-apatite but whether it is intrusive into the magnetite-apatite or included within it, is not clear. The minerals of these orebodies magnetite, apatite, sulphides, pyrochlore, aegirinaugite, are also common to ijolite, malignite and carbonate rock and to the metasomatized gneiss outside the nepheline syenite."

"The hypothesis is proposed that the magnetite-apatite bodies were intruded into steeply dipping cone-sheet fractures and zones of brecciation within the malignite. Foliation is attributed to flow banding and their mineral composition to crystallization from fluids very similar to those responsible for the alteration of the regional gneiss and the formation of ijolites and malignites. It is concluded that the magnetite-apatite bodies formed from aqueous solutions rich in iron, lime and components of the accessory minerals and some CO_2."

DESCRIPTIONS OF DEPOSITS

FRONTENAC COUNTY

Bedford Township

Martin Occurrence

Location: Lot 4, concession II, Bedford township, Frontenac county.

Minerals Present: Apatite, phlogopite, pyroxene.

Development: Worked early in the century by A. Martin and John Bragg. A shaft 40 feet deep was sunk.

Geology: Vein of apatite, phlogopite and pyroxene cuts pink paragneiss which strikes N27°E and dips 30 to 60 degrees southeast.

Reference: Harding (1947, p. 36).

Lot 6, Concession IV

Location: Lot 6, concession IV, Bedford township, Frontenac county.

Minerals Present: Apatite.

Reference: Spence (1920, p. 44).

Bobs Lake or Taggart Mine

Location: Lot 30, concession VI, Bedford township, Frontenac county.

Minerals Present: Apatite and phlogopite.

Development: The earliest mining was carried out in 1891 by the Montreal Mining Company, in a search for phosphate. Later mica was discovered by William Lewis, and mica was produced from 1897 to 1900 by Tom Taggart of Westport. Mica was produced by Kent Bros. and Stoness from 1903 to 1925. Other operators of the Bobs Lake mine were William Lee, S.O. Fillion and William Kent. In 1945 some mica was produced by Clayton Orser and Damon Smith. Production came from a series of closely spaced parallel veins worked by separate open pits. Some of the named workings were the Taggart, Butternut, Jones and King pits. The largest of several old workings is 125 feet long, 9 feet wide and about 125 feet deep.

Geology: Mica and phosphate occur in parallel veins 2 to 9 feet wide cutting altered greywackes and other Grenville metasediments.

References: Harding (1947, p. 86); Spence (1920, p. 42); de Schmid (1912, p. 159).

Lot 7, Concession VII

Location: Lot 7, concession VII, Bedford township, Frontenac county.

Minerals Present: Apatite.

Development: Reported to have been worked in a small way.

Reference: Spence (1920, p. 44).

Hilliard Bedore Occurrence

Location: Lot 32, concession VII, Bedford township, Frontenac county. Near the north shore of Bobs Lake.

Minerals Present: Apatite, phlogopite, pink calcite, pyroxene.

Development: Three or four dozen pits and trenches were put down, the largest of which is 75 feet by 40 feet and 25 feet deep. Between 1880 and 1890 phosphate was produced by R.C. Adams and the Anglo-Canadian Phosphate Company.

Geology: Apatite occurs in massive form and in crystals. Calcite, apatite, pyroxene, phlogopite veins strike northeast parallel to the north shore of Bobs Lake. The veins dip vertically. Most of the veins are less than 5 feet wide. The country rock is Precambrian greywacke striking northeast and dipping 40 to 80 degrees southeast.

References: Spence (1920, p. 43); Harding (1947, p. 36).

McLaren Mine

Location: Lots 25, 27, 28, 29, concession X, Bedford township, Frontenac county. Shaft on lot 27.

Minerals Present: Apatite, hornblende, pyroxene, calcite, phlogopite, pyrite, actinolite.

Development: Apatite was produced at the McLaren mine between 1888 and 1890 by Edmund Watts and Peter McLaren from shallow pits scattered over a belt 1200 feet long. About 500 tons of apatite are reported to have been shipped. The deepest of the early workings was about 35 feet. In 1941 or 1942 Canadian Phosphate Mining Company was formed by Bruce Robson. In 1942 this company produced 244 tons of apatite. Later in 1942 the company optioned the property to Pioneer Gold

Mines Limited who in the fall did 1521 feet of diamond drilling in 10 holes in the northeastern section of the property. The drilling indicated some apatite present at a shallow depth but the option was dropped. C. Riley of Toronto operated the property in 1943 and shipped 68 tons of apatite from the Riley pit on lot 28. Later in 1943 the property was leased to H.C. Cordick and 147 tons of phosphate were produced. During 1943 an additional 102 tons of phosphate were mined by Canadian Phosphate Mining Company who still owned the property. Production in 1943 was from the Cordick pit.

Later the property was taken over by Ontario Phosphate Industries Limited. During 1944 eight drill holes totalling 2234 feet were drilled. During 1944 and 1945 a vertical 3 compartment shaft was sunk to depth of 175 feet; at the 150-foot horizon a crosscut was run northwest from the shaft for 245 feet; 411 feet of drifting was carried out and 25 feet of raising. Harding (1947, p. 39) states that the results of underground exploration were disappointing. Small lenses and veins of apatite were encountered in crosscutting and drifting but none of the bodies was of sufficient size to yield more than a ton or two of apatite. The drift, which was designed to follow the main apatite-bearing zone where bodies of apatite were thought likely to exist, was largely in barren rock.

Geology: The country rocks are largely pink and grey granitized paragneiss. Apatite occurrences are largely confined to a northeastward-striking belt of gneiss over 1200 feet long and 150 feet wide. Veins and lenses of green apatite are widespread. The best showings are in the Riley and Cordick pits. The strike and dip of most of the apatite veins conform approximately to the strike and dip of the enclosing gneisses.

References: Spence (1920, p. 43); Harding (1947, p. 37).

Lot 28, Concession XI

Location: Lot 28, concession XI, Bedford township, Frontenac county. Near the northeast shore of Wolf or West Rideau Lake.

Minerals Present: Apatite, phlogopite.

Development: Worked by W.J. Webster of Westport in 1890 and intermittently until 1903.

Reference: Spence (1920, p. 43-44).

Opinicon Lake Mine

Location: Lot 1, concession XVII, Bedford township, Frontenac county.

Minerals Present: Green and red apatite.

Development: Mine opened in 1870 by Alexander Cowan; by the end of 1871 about 550 tons of apatite were mined. Mining was resumed in 1892 for a year; a pit 50 feet deep was sunk and 150 feet of vein was opened.

Geology: Apatite leads 2 to 4 feet wide.

Reference: Spence (1920, p. 44).

Lot 3, Concession XII

Location: Lot 3, concession XII, Bedford township, Frontenac county.

Minerals Present: Apatite.

Development: Worked in a small way.

Reference: Spence (1920, p. 44).

Hinchinbrooke Township

Hickey Occurrence

Location: Lot 2, concession I, Hinchinbrooke township, Frontenac county.

Minerals Present: Apatite.

Development: A pit about 30 feet long and 10 feet deep was sunk in gneiss near a band of crystalline limestone.

Geology: Country rock consists of northeastward-striking granite gneiss containing bands of paragneiss and marble.

Reference: Harding (1947, p. 35).

Eagle Lake Mine

Location: Lots 29 and 30, concession I, Hinchinbrooke township, Frontenac county.

Minerals Present: Apatite, magnetite, hornblende, pyroxene, calcite.

Development: Numerous pits over a length of 400 feet; shaft to 175 feet. Operated for phosphate from 1887 to 1891 by Boyd Smith with a production of 4000 tons of apatite.

Geology: Veins of apatite and magnetite 6 inches to 6 feet wide cut Grenville gneiss. The veins strike northeast - southwest and are traceable over the length of a mile. The apatite occurs in pockets and chimneys.

References: Spence (1920, p. 44); Harding (1947, p. 35).

Kenehan Occurrence

Location: Lot 2, concession II, Hinchinbrooke township, Frontenac county.

Minerals Present: Apatite.

Development: Pit sunk by Lake and Taggart in 1907 measures 30 by 15 feet and 35 feet deep.

Geology: An apatite vein 2 feet wide strikes east-west, cutting granite and granite gneiss.

Reference: Harding (1947, p. 35).

Ernie Campsall Occurrence

Location: Lot 3, concession II, Hinchinbrooke township, Frontenac county.

Minerals Present: Apatite, magnetite, calcite.

Development: Six-foot pit; property diamond drilled by 3 holes 24 feet, 112 feet and 674 feet in 1950 by Quebec Smelting and Refining Limited. Optioned to Strategic Metals Limited in 1953.

Geology: Fine-grained apatite and magnetite is disseminated in medium-grained white crystalline limestone. In places the apatite makes up as much as 25 percent of the rock.

Reference: Harding (1947, p. 36).

Loughborough Township

Lacey Mine

Location: W½, lot 11, concession VII, Loughborough township, Frontenac county.

Minerals Present: Apatite, mica.

Development: Worked for phosphate in 1882, then mica. Production of about 200 tons of phosphate. One large open pit.

Geology: Apatite and phlogopite in pipe-like mass.

Reference: Spence (1920, p. 45).

Coe Mine

Location: W½, lot 5, concession IX, Loughborough township, Frontenac county. Near Gould Lake.

Minerals Present: Apatite, mica.

Development: First opened in the 1880's by Mr. Coe, it was later worked by C. Sterling, and Webster and Company. The property has been worked for apatite and mica. There is one deep pit and several surface workings. Production is reported at 150 tons of phosphate.

Geology: The phosphate leads are narrow.

Reference: Spence (1920, p. 46).

Amey Mine

Location: E½, lot 13, concession VIII, Loughborough township, Frontenac county.

Minerals Present: Phlogopite, apatite, calcite, pyroxene.

Development: First worked in the 1870's by Mr. N. Amey for phosphate, and later by Webster and Company, Mica Product Company and the Loughborough Mica Company. There are numerous pits on the property, ranging from 20 to 100 feet deep and up to 8 feet wide.

Geology: Veins of calcite carry mica and phosphate striking northwest and southeast.

Reference: de Schmid (1912, p. 148-9).

Lot 6, Concession IX

Location: Lot 6, concession IX, Loughborough township, Frontenac county.

Minerals Present: Apatite, mica.

Development: An old phosphate mine worked many years ago by Smith and Lacey of Sydenham. Also worked by Webster and Company.

Geology: The country rock is pinkish garnetiferous granite gneiss.

Reference: de Schmid (1912, p. 149).

Lot 7, Concession IX

Location: Lot 7, concession IX, Loughborough township, Frontenac county.

Minerals Present: Apatite, phlogopite in pink calcite.

Development: Worked for phosphate and mica by J.W. Trousdale of Sydenham.

Geology: Vein of pink calcite carries mica and apatite.

References: de Schmid (1912, p. 149); Spence (1920, p. 46).

Lot 16, Concession IX

Location: Lot 16, concession IX, Loughborough township, Frontenac county.

Minerals Present: Apatite, mica.

Development: About 100 tons of apatite was mined from the property in 1890 and 1891 by C. Sterling of Kingston as a by-product of mica mining.

Reference: Spence (1920, p. 46).

Gould Lake Mine

Location: Lots 6 and 7, concession X, Loughborough township, Frontenac county.

Minerals Present: Apatite, mica.

Development: Opened in early 1880's as a phosphate mine by T. Holland. Subsequently mined for phosphate and mica by Smith and Lacey. Taken over in 1910 by the Birch Lake Mining Syndicate. The Holland pit is 115 feet deep, 100 feet long at

the bottom and 12 feet wide. A parallel lead was worked to a depth of 110 feet. The Woodruffe pit is 85 feet deep.

Geology: The fissure-filling calcite veins carry apatite and mica, and strike north-south. They occur in grey pyroxenite enclosed in grey to red gneiss.

References: de Schmid (1912, p. 152-3);
Spence (1920, p. 46).

McClatchey Mine

Location: Lot 8, concession X, Loughborough township, Frontenac county.

Minerals Present: Apatite, mica, calcite, pyrite.

Development: Worked in the early phosphate days by Messrs. Freeman and Snyder of Perth Road, who subsequently sold to Messrs. McClatchey and Hayden of Belleville who commenced operations for mica. In 1901 the property was acquired by J.W. Trousdale of Sydenham who operated for several years. Workings include several surface pits and a shaft down 100 feet.

Geology: The leads are calcite with apatite, mica and pyrite in grey pyroxenite which cuts garnetiferous dark gneiss.

Reference: de Schmid (1912, p. 153).

Lot 10, Concession X

Location: Lot 10, concession X, Loughborough township, Frontenac county.

Minerals Present: Apatite, mica.

Development: Worked first by Mr. Sloan of Perth about 1897 and subsequently by W. Mace of Tamworth in 1898. In 1908 the mine was worked for a year by the Excelsior Mining Company of Toronto. There were 6 pits, the largest being 40 feet deep.

Geology: The apatite and mica occur on more or less parallel fissures in red granite gneiss underlain by pyroxenite.

References: de Schmid (1912, p. 153); Spence (1920, p. 47).

Foxton Mine

Location: Lot 13, concession X, Loughborough township, Frontenac county.

Minerals Present: Apatite, pyroxene, scapolite, epidote, mica.

Development: Mining was commenced by James Foxton of Perth Road in 1886 and continued until 1892 with the production of over 5000 tons of apatite. The apatite vein was 2½ feet wide at surface, 10 feet wide at 50 feet and 15 feet wide at 115 feet.

Geology: The apatite vein is almost vertical and occurs in coarse-grained, greenish-grey pyroxene enclosed in dark gneiss. The strike is northwest-southeast.

Reference: Spence (1920, p. 47-8).

Bear Lake Mine

Location: Lot 18, concession XI, Loughborough township, Frontenac county.

Minerals Present: Mica, apatite, calcite.

Development: First produced phosphate, then mica. The property was worked by W. Wallace of Perth Road and by J.H. Roberts of Perth Road from 1900 to 1906. The main pit is 105 feet deep and is sunk on an incline. There are numerous surface pits.

Geology: The calcite vein carrying mica and apatite is on the contact of pyroxenite and gneiss, with a northeast strike and an average width of 12 feet. The main lead has been traced for 1400 feet on surface.

Reference: de Schmid (1912, p. 154).

Lot 20, Concession XI

Location: Lot 20, concession XI, Loughborough township, Frontenac county.

Minerals Present: Mica, apatite.

Development: The property produced phosphate, then mica; few surface pits were opened, none exceeding 20 feet in depth. Work was begun by Kent Bros. and Stoness in 1903.

Reference: de Schmid (1912, p. 154).

Birch Lake Mine

Location: Lot 14, concession XIV, Loughborough township, Frontenac county.

Minerals Present: Mica, apatite, calcite, pyroxene.

Development: This mine was worked in the early phosphate days by Mr. McKay of Wisconsin and was acquired in the early 1890's by Webster and Company who mined for mica. It was later worked by the Birch Lake Mining Syndicate. A 75-foot shaft was sunk on an incline of 80° southwest.

Geology: Fissure veins of calcite, mica and apatite in pyroxenite strike northwest and southeast.

Reference: de Schmid (1912, p. 154-5).

Olden Township

Vinkle Occurrence

Location: Lot 3, concession X, Olden township, Frontenac county.

Minerals Present: Apatite, calcite.

Development: Pit 10 feet deep. Early work done by John Taggart of Westport, with further work by John Laurie of Perth and John Vinkle.

Geology: Green apatite in irregular masses and well-formed crystals in pink calcite in a vertically-dipping vein striking north-south. The vein cuts light-coloured paragneiss.

Reference: Harding (1947, p. 33).

Oso Township

St. George Lake Mine

Location: Lot 6, concession I, Oso township, Frontenac county.

Minerals Present: Apatite, calcite, hornblende, mica, pyrite and pyroxene.

Development: This was one of the largest phosphate mines in the district and was opened in 1885 by Mr. Boyd Smith of Washington,D.C. It operated until 1891 producing approximately 1500 tons. One pit measures 200 feet long, 40 feet wide and 50 feet deep. A second pit measures 100 feet by 25 feet by 65 feet deep.

Geology: The apatite occurs in a vein striking northeast-southwest and dips 40 degrees southeast. The footwall is marble, and the hangingwall reddish gneiss.

References: Spence (1920, p. 48); Harding (1947, p. 34).

Lot 2, Concession V

Location: Lot 2, concession V, Oso township, Frontenac county.

Minerals Present: Apatite, mica, pyroxene, calcite.

Development: The mine was opened for phosphate about 1890 by Messrs. Wilson and McMartin of Perth. In 1905 the General Electric Company worked the mine for mica. There are several surface pits.

Geology: Apatite-phlogopite veins are up to 4 feet wide and cut paragneiss.

References: de Schmid (1912, p. 163); Spence (1920, p. 49); Harding (1947, p. 76).

Silver Lake Mine

Location: Lot 14, concession VI, Oso township, Frontenac county.

Minerals Present: Apatite, phlogopite, hornblende, pyroxene, magnetite.

Development: The mine was opened for phosphate in 1891 by Wm. Davis of Perth, and was subsequently acquired by Boyd Smith of Washington, D.C. Some 250 tons of apatite were produced. There are more than 20 pits, most of them shallow.

Geology: Veins and lenses of pinkish-brown apatite cut pink gneiss and mafic intrusives. The country rock is pink syenite gneiss grading into diorite and gabbro.

References: Spence (1920, p. 49); Harding (1947, p. 34).

Lots 2 and 3, Concession VII

Location: Lots 2 and 3, concession VII, Oso township, Frontenac county.

Minerals Present: Apatite, mica.

Development: Worked by T. Cooke of Harrowsmith for mica and phosphate. The workings are surface pits.

Reference: de Schmid (1912, p. 163).

Storrington Township

Morris Mine

Location: Lot 14, concession VI, Storrington township, Frontenac county.

Minerals Present: Apatite, mica.

Development: About 300 tons of apatite were produced about 1880 by W.J. Morris.

Geology: A narrow lead averaging under 12 inches in width carries red phosphate and mica.

Reference: Spence (1920, p. 49).

Lot 2, Concession XIII

Location: Lot 2, concession XIII, Storrington township, Frontenac county.

Minerals Present: Apatite.

Development: Worked by William Mace.

Reference: G.S.C. map sheet, Westport, 28-1959.

Bawden Mine

Location: Lots 4 and 5, concession XIV, Storrington township, Frontenac county.

Minerals Present: Apatite, mica.

Development: Messrs. Bawden and Machar mined about 500 tons of phosphate in 1885. The property was worked for mica in 1900.

Reference: Spence (1920, p. 50).

Opinicon or Rock Lake Mine

Location: Lot 21, concession XV, Storrington township, Frontenac county.

Minerals Present: Red to green massive crystalline phosphate.

Development: James Bell of Arnprior mined 500 tons of phosphate in 1888 and 1889. The Kingston Phosphate Company mined the property in 1891 and 1892. An inclined pit 75 feet long was sunk on a 45° incline to 225 feet. A second pit 40 feet deep measured 20 by 30 feet, widening as it went down. About 1500 tons of phosphate was produced.

Geology: The vein widened from 2 feet at the surface to 8 feet at 225 feet depth.

Reference: Spence (1920, p. 50).

HALIBURTON COUNTY

Cardiff Township

Location: Lot 22, concession XIX, Cardiff township, Haliburton county.

Minerals Present: Green-brown apatite crystals in white calcite.

Development: Pit 8 by 4 feet and 2 feet deep.

Geology: The country rock is granite.

Reference: Satterly (1943, p. 20).

Monmouth Township

Millar's Phosphate Mine

Location: Lot 15, concession XI, Monmouth township, Haliburton county.

Minerals Present: Apatite, calcite, hornblende, phlogopite, titanite.

Development: The mine was worked about 1900; there are several pits and an adit. There is a trench 45 feet long, 4 to 5 feet wide and 8 feet deep.

Geology: A carbonate vein 2 to 5 feet wide trending N40°W carries apatite. The country rock is graphic granite pegmatite.

Reference: Satterly (1943, p. 20).

HASTINGS COUNTY

Faraday Township

William Card Farm

Location: Lot 14, Monck Road North, Faraday township, Hastings county, farm of William Card.

Minerals Present: Apatite, calcite, pyroxene, titanite, zircon.

Development: Pit 20 feet by 4 feet by 5 feet deep.

Geology: Fissures and vugs in crystalline limestone inclusions in red granitic rock are filled with crystals of calcite, apatite, titanite and pyroxene.

Reference: Thomson (1943, p. 15-16).

Miner Card Farm

Location: Lot 16, Monck Road North, Faraday township, Hastings county, farm of Miner Card.

Minerals Present: Apatite, fluorite, cyrtolite, pyroxene, hornblende, titanite and feldspar.

Development: Opening 25 by 3 feet by 5 feet deep.

Geology: A fissure in pink granite is lined with crystals of apatite, quartz, fluorite, pyroxene, hornblende, cyrtolite and pink feldspar. The fissure filling is calcite, apatite and titanite. Radioactive minerals are reported.

Reference: Thomson (1943, p. 16).

LANARK COUNTY

Bathurst Township

Lot 11, Concession VIII

Location: Lot 11, concession VIII, Bathurst township, Lanark county.

Minerals Present: Apatite.

Reference: Spence (1920, p. 59).

North Burgess Township

Lot 16, Concession III

Location: Lot 16, concession III, North Burgess township, Lanark county.

Minerals Present: Red apatite.

Development: One hundred tons of apatite was mined from this lot in 1871 by M. Philips.

Reference: Spence (1920, p. 50-51).

Lot 11, Concession IV

Location: Lot 11, concession IV, North Burgess township, Lanark county.

Minerals Present: Apatite.

Development: The mine was worked in 1871 by S. Clark of Sherbrooke.

Reference: Spence (1920, p. 51).

Lots 3 and 4, Concession V

Location: Lots 3 and 4, concession V, North Burgess township, Lanark county.

Minerals Present: Apatite, mica.

Development: The mine was worked as early as 1867 by the Rideau Mining Company. Six narrow pits were put down on parallel leads of apatite and mica. The average width of the pits is 5 feet and the deepest pit has a depth of 75 feet. The mine was worked for phosphate and mica.

Geology: Parallel leads of phosphate and mica strike northwest and southeast.

Reference: de Schmid (1912, p. 164-5), Spence (1920, p. 51).

Mahon Occurrence

Location: Lot 10, concession V, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite.

Development: Workings consist of open pits. This was an old phosphate producer worked later for mica.

Geology: Mica-apatite-calcite leads strike N75°E. The country rock is green pyroxenite.

Reference: de Schmid (1912, p. 166).

Silver Queen Mine

Location: E½, lot 13, concession V, North Burgess township, Lanark county.

Minerals Present: Fine-grained, greenish-white, sugar phosphate, mica, pyrite, diopside, garnet, tremolite, graphite, actinolite.

Development: The mine produced mica and apatite from 1903 to 1912 under the direction of R. McConnell and later C. Ellsner. The orebody has been mined by three pits, the chief of which was sunk vertically for 35 feet, from which point an inclined stope was carried 65 feet to the northwest, drifts being run along the deposit in a northeast direction. The total length of the pit is about 60 feet.

Geology: The deposit occurs on the contact of a pyroxenite dike with gneiss and crystalline limestone and has a direction of N30°E with a dip to the northwest.

References: de Schmid (1912, p. 167); Spence (1920, p. 51).

Baby Mine

Location: W½, lot 13, concession V, North Burgess township, Lanark county.

Minerals Present: Apatite, phlogopite, calcite, scapolite.

Development: A former phosphate producer, the lease was obtained in 1893 by the Lake Girard Mica System and a pit was sunk to a depth of nearly 100 feet. In 1903 T.J. Smith secured an option and worked the property until it was taken over by the Kingston Feldspar Mining Company. Several surface pits were opened up.

Geology: The apatite and mica leads occur in fissure veins in pyroxenite.

Reference: de Schmid (1912, p. 168).

Donnelly Mine

Location: Lot 16, concession V, North Burgess township, Lanark county.

Minerals Present: Apatite, mica in pink calcite.

Development: Opened prior to 1870 as a phosphate producer, it later produced mica. Several pits were put down on the vein the largest being 35 feet long, 6 feet wide and 35 feet deep. The early producer was R. Leekie and Company; it was later operated in 1901 by Gemmell and Thompson of Perth. Subsequently mining was done by McConnell, Gemmell and Ewen and in 1905 by Thompson and Noonan. Apatite production was approximately 100 tons.

Geology: A vein of pink calcite with apatite and phlogopite has a length of 150 feet, a width of 8 feet at the bottom of the pit and strikes northwest with a dip of 80° northeast. The vein is on the contact of gneiss and pyroxenite.

References: de Schmid (1912, p. 169); Spence (1920, p. 53).

Lots 18 and 19, Concession V

Location: Lots 18 and 19, concession V, North Burgess township, Lanark county.

Minerals Present: Apatite.

Development: Two pits 40 feet deep. Production of approximately 200 tons of phosphate in 1871 by Matheson and Bell.

Reference: Spence (1920, p. 53).

McMartin Mine

Location: Lot 1, concession VI, North Burgess township, Lanark county.

Minerals Present: Apatite.

Development: Worked extensively in the early phosphate days.

Reference: Spence (1920, p. 53).

Old Anthony Mine

Location: Lot 10, concession VI, North Burgess township, Lanark county.

Minerals Present: Red apatite, mica.

Development: The mine was operated in 1871, 1873-4 and 1906. The workings extend to a depth of over 125 feet.

Geology: A four-foot wide vein strikes N35°E and occurs on the contact of dark green pyroxenite with red granite gneiss.

References: de Schmid (1912, p. 170); Spence (1920, p. 54).

Hanlon Mine

Location: Lot 11, concession VI, North Burgess township, Lanark county.

Minerals Present: Mica, apatite, calcite.

Development: The mine was opened in the late 1890's and worked until 1901 by Webster and Company. It was operated from 1901 to 1909 by the General Electric Company. The workings reached 175 feet in depth, the lead having been stoped out for a distance of 200 feet at the bottom. 50 feet north of the main pit a shaft was sunk to 35 feet depth.

Geology: The vein strikes northeast and southwest and dips 75°SE. The greatest width is 20 feet. The country rock is pyroxenite.

Reference: de Schmid (1912, p. 171).

Old Adams or Klondyke Mine

Location: Lot 12, concession VI, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite.

Development: This mine was exploited for mica and phosphate. There are several pits and shafts, none exceeding 40 feet in depth. The mine was originally opened for phosphate and was worked after 1901 by the General Electric Company. In 1906 the mine was worked by Watts and McConnell. The main pit is 60 feet long.

Geology: The main leads of calcite, apatite and mica run north and south, and are associated with spurs of light grey pyroxenite cutting granite gneiss. Large bodies of pink calcite containing green apatite occur in pockets along the veins.

Reference: de Schmid (1912, p. 172).

Martha Mine

Location: E½, lot 13, concession VI, North Burgess township, Lanark county.

Minerals Present: Mica, apatite, calcite, scapolite.

Development: The mine was opened about 1871 for phosphate and later worked for mica. In 1891 Lake Girard Mica System took over the property and carried on extensive work for 2 years. In 1893 the mine was purchased by the Mica Manufacturing Company of London and worked until 1902. In 1905 the mine was worked by Messrs. Sewell and Smith. A main pit and several smaller pits were put down on the vein.

Geology: The vein of mica, calcite, apatite and scapolite was 25 feet wide and cut augite syenite.

Reference: de Schmid (1912, p. 172).

Munslow Mine

Location: W½, lot 13, concession VI, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite.

Development: The mine was first worked for phosphate in 1871 by Edward Schultze who opened several surface pits. The mine was worked for mica from 1891 to 1907 by T.J. Smith of Micaville. The main pit is 200 feet long, 15 to 20 feet wide, and 130 feet deep.

Geology: Mica and apatite are associated with a series of pyroxenite bands cutting gneiss, the total width of pyroxenite being 100 feet. The general strike of the leads is N20°E.

Reference: de Schmid (1912, p. 173).

Star Hill Mine

Location: Lots 20 and 21, concession VI, North Burgess township, Lanark county.

Minerals Present: Phlogopite, green apatite, calcite, feldspar.

Development: The property was owned by Messrs. Wilson and Greene of Montreal and was worked by P.C. McParland of Westport, Messrs. Clemow and Powell of Ottawa, and Messrs. Thompson, Donnelly and Gemmell. The old workings reached a depth of 50 feet, the newer pits do not exceed 25 feet. The main opening is an open cut 22 feet deep driven into the side of a ridge. This cut was driven on a mica lead 3 feet wide which pinched out along strike.

Geology: The mica-apatite leads trend northeast and southwest with a dip to the northwest. The minerals occur in pockets and fissures in pyroxenite. Some leads carry pink calcite. Mica generally occurs on the hangingwall contact of pyroxenite with country rock gneiss.

Reference: de Schmid (1912, p. 174).

Lot 9, Concession VII

Location: Lot 9, concession VII, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite.

Development: Two narrow pits 35 and 90 feet deep were opened in 1883 on well defined parallel leads of apatite and mica. The total tonnage of apatite produced was estimated at 2000 tons. The mine was later worked for mica by Edward Smith of Perth from 1904 to 1906. The main pit is 90 feet deep, 65 feet long and 5 feet wide. Several other openings were carried to depths of 40 to 50 feet.

Geology: Mica, apatite and calcite occur in fissures in a series of narrow pyroxenite dikes cutting granite gneiss in a northwest-southeast direction.

References: de Schmid (1912, p. 175); Spence (1920, p. 54).

Otter Mine

Location: E½, lot 11, concession VII, North Burgess township, Lanark county.

Minerals Present: Mica, brown phosphate, calcite.

Development: The mine was worked about 1891 by Messrs. Cross and Foster and later by Mr. McLaurin of Perth. Initial work on the property was carried out about 1870 and an estimated 2000 tons of phosphate was produced. There are a number of small pits, the largest being 45 by 8 feet and 35 feet deep.

Geology: Leads of mica and apatite strike N20°E and dip 80°SE at the contact of pyroxenite and dark gneiss.

References: de Schmid (1912, p. 175); Spence (1920, p. 54).

Byrne's Mine

Location: W½, lots 11 and 12, concession VII, North Burgess township, Lanark county.

Minerals Present: Red apatite, hematite, pyrite, mica.

Development: The mine was opened by A. Cowan in 1870. Several pits were opened, the largest being about 55 feet deep. It operated until 1874 producing about 1500 tons of apatite. The property was later mined for mica by P. Byrne and in 1901 by the General Electric Company.

Geology: Narrow leads carry mica and phosphate trending northwest and southeast. The veins seldom exceed 10 feet in width and occur marginal to and within pyroxenite.

References: de Schmid (1912, p. 176); Spence (1920, p. 55).

Otty Lake Mine

Location: Lot 1, concession VIII, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, scapolite, pyrite, marcasite.

Development: The mine was worked in 1871 by Edward Schultze, in 1873 by Messrs. Morris and Griffin and in 1908 to 1910 by R. McConnell. The main opening is 100 feet long, 15 feet wide and about 40 feet deep.

Geology: Mica and apatite occur in pink calcite at the contact of dark pyroxenite and dark biotite gneiss. The mica crystals are badly crushed.

References: de Schmid (1912, p. 176); Spence (1920, p. 55).

Lot 2, Concession VIII

Location: Lot 2, concession VIII, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite, scapolite, wilsonite.

Development: This phosphate mine is reputed to be the first worked in Canada having been opened in 1855. It was worked in 1870 by R. Matheson of Perth who opened a pit 60 feet long and 15 feet deep. The property was acquired by Kent Brothers in 1907 and the largest pit was 60 feet long, 25 feet wide and 25 feet deep.

Geology: Mica and apatite occur irregularly in pockets in leads in light grey pyroxenite.

Reference: Spence (1920, p. 55).

Lot 3, Concession VIII

Location: Lot 3, concession VIII, North Burgess township, Lanark county.

Minerals Present: Apatite, mica.

Development: Apatite was mined on this lot in 1870 from an 8-foot vein by Messrs. Ritchie and Jackson of Belfast. A shaft was sunk to 30 feet on a 3-foot vein and drifting was carried out in both directions on the vein. Several smaller pits were opened and about 1000 tons of apatite is said to have been mined. The mine was worked in 1908 by Kent Brothers of Kingston for mica.

Geology: The mica-apatite veins strike northwest and southeast and average 2 feet in width. Narrow bands of pyroxenite separate the veins from the country rock quartz-syenite.

References: de Schmid (1912, p. 178); Spence (1920, p. 56).

MacLaren Mine

Location: Lots 4,5 and 6, concession VIII, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite.

Development: Mining for phosphate on these lots commenced about 1870 by Watts Bros. of Perth. Over 200 tons of apatite were mined. Between 1878 and 1883 these lots were worked by P.C. Adams of Montreal and over 5000 tons of apatite was produced. In 1888 the Anglo-Canadian Phosphate Company acquired the property and mined about 2000 tons of apatite. The main pits were 100 and 80 feet deep. Several smaller pits were opened up. One promising lead was opened up to a depth of 75 feet, the cut being 10 feet wide.

Geology: The mica-apatite leads strike northwest-southeast and dip vertically. Some of the leads can be traced for a length of 200 feet.

References: de Schmid (1912, p. 178); Spence (1920, p. 56).

Lot 4, Concession IX

Location: Lot 4, concession IX, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite.

Development: The property was worked by Messrs. Watts, Adams and Noble. The mine was originally worked for apatite, and numerous old pits exist. The largest

pit is 15 feet long, 6 feet wide and 30 feet deep. The mine has been worked both for apatite and mica.

Geology: The main pit exposes a vein of mica, green apatite and pink calcite between walls of pyroxenite. The vein strikes northwest and southeast and has a width of about 5 feet.

References: de Schmid (1912, p. 179); Spence (1920, p. 57).

Lot 6, Concession IX

Location: Lot 6, concession IX, North Burgess township, Lanark county.

Minerals Present: Apatite, mica, calcite.

Development: A large number of pits have been opened for phosphate on this lot. The property was worked in 1906 by Messrs. Adams and Noble of Perth and in 1910 by J.H. Mendels.

Geology: Leads of mica and apatite with some calcite strike N75°W.

References: de Schmid (1912, p. 180); Spence (1920, p. 57).

North Elmsley Township

Lot 25, Concession VIII

Location: Lot 25, concession VIII, North Elmsley township, Lanark county.

Minerals Present: Apatite, calcite.

Development: Work on the property was done prior to 1870 and over 100 tons of phosphate was raised.

Geology: A vein of pink calcite 10 feet wide carries apatite.

Reference: Spence (1920, p. 58).

LEEDS COUNTY

Bastard Township

Lot 14, Concession III

Location: Lot 14, concession III, Bastard township, Leeds county.

Minerals Present: Mica, apatite.

Development: The mine was first worked in 1906 by J. Stoness of Perth Road. In 1908 H. Adams carried out mining. About 18 tons of apatite were extracted, together with brittle yellow mica. There are 2 pits, one being down 20 feet.

Geology: Leads of mica and apatite strike east-west and cut decomposed pyroxenite.

Reference: de Schmid (1912, p. 191).

South Burgess Township

Cantin Mine

Location: Lot 1, concession IV, South Burgess township, Leeds county.

Minerals Present: Apatite, mica, calcite, pyrite.

Development: The mine was worked for apatite in the early 1870's and later for mica by Webster and Company, and the General Electric Company. The main pit is 110 feet deep, 85 feet long and 12 to 25 feet wide.

Geology: Mica and apatite are disseminated in pockety aggregates in a vein of compact pinkish-white calcite, which strikes N80°E. The vein occurs at the contact of pyroxenite and granite gneiss.

Reference: Spence (1920, p. 58).

South Crosby Township

Sand Lake Mine

Location: Lots 14 and 15, concession VII, South Crosby township, Leeds county.

Minerals Present: Apatite, mica, pyrite, calcite.

Development: The mine was opened for apatite in the 1870's and was later worked for mica. It was worked in 1900 by the Brockville Mining Company and later by Messrs. Mendels and Smith of Perth. The main pit is 25 feet in diameter and 75 feet deep.

Geology: A chimney-like pipe of pyroxenite carries aggregates of mica and apatite.

References: de Schmid (1912, p. 187); Spence (1920, p. 58).

RENFREW COUNTY

Ross Township

Ross Occurrence

Location: Lot 4, concession VI, Ross township, Renfrew county.

Minerals Present: Apatite, calcite, fluorite, zircon.

Development: There are two prospect pits; the west one is 10 feet in diameter and 4 feet deep; the east one is 30 feet long, 10 feet wide and 4 feet deep.

Geology: Reddish-brown apatite crystals occur in calcite which forms part of a hornblende-microcline pegmatite.

Reference: Satterly (1944, p. 17).

Elliott's Mine

Location: Lot 7, concession IX, Ross township, Renfrew county.

Minerals Present: Apatite, scapolite, titanite, calcite, fluorspar, spinel, hornblende.

Development: Several openings have been made on a limestone band containing apatite. Production of about one ton of apatite was reported in 1883.

Geology: A limestone band contains an abundance of apatite, scapolite, hornblende and titanite crystals.

Reference: Satterly (1944, p. 17).

Sebastopol Township

Smart Mine

Location: Lot 31, concession X, Sebastopol township, Renfrew county.

Minerals Present: Apatite, zircon, titanite, calcite.

Development: The mine was opened prior to 1880 and yielded a considerable quantity of phosphate.

Geology: A band of crystalline limestone carries fine crystals of zircon, titanite and apatite.

Reference: Satterly (1944, p. 17).

Meany Mine

Location: Lot 31, concession XI, Sebastopol township, Renfrew county.

Minerals Present: Apatite, pyroxene, calcite.

Development: Several pits have been opened on the property. The mine was first opened in 1880 and in the following three years 300 tons of apatite were mined. The largest pit is 25 feet in depth.

Geology: The deposit is a mixed vein of apatite and pyroxene, intersected by veins of pink calcite. The vein strikes northeast and southwest and varies from 6 to 16 feet in width.

Reference: Satterly (1944, p. 18).

Park Mine

Location: Lot 23, concession XII, Sebastopol township, Renfrew county.

Minerals Present: Apatite, calcite, orthoclase, hornblende, pyroxene.

Geology: Walls of fissures in crystalline limestone are lined with crystals of apatite, orthoclase, hornblende and pyroxene.

Reference: Satterly (1944, p. 18).

Turner's Island

Location: Turner's Island, Clear Lake, Sebastopol township, Renfrew county.

Minerals Present: Apatite, calcite, titanite, scapolite, pyroxene, hornblende.

Development: Apatite was first mined on Turner's Island in 1879 and up to 1882 about 200 tons were produced. The largest working is near the north point of the island and is an open cut 175 feet long, 3 to 15 feet wide and 2 to 12 feet deep.

Geology: The vein, consisting of salmon-orange calcite containing apatite, trends N70°E and dips 55° south. The vein is 4 to 10 feet wide. Titanite is an accessory. The footwall of the vein consists of large crystals up to 6 inches in diameter of scapolite, pyroxene and apatite.

Reference: Satterly (1944, p. 18).

DISTRICT OF SUDBURY

McNaught and Lackner Townships

Multi-Minerals Limited

Location: 75 claims in McNaught and Lackner townships, District of Sudbury, 7 miles northeast of Nemegos station.

Minerals Present: Magnetite, apatite, pyrochlore, calcite.

Development: Magnetic and geological surveys as well as extensive diamond drilling from 1953 to the present. Mill and metallurgical test work. Diamond drilling has outlined several ore zones. Zones 3 and 4 are estimated to contain 37,000,000 tons grading 21.3% apatite, 13.7% magnetite and 0.198% columbium oxide. No. 6 zone is estimated to contain 5,024,250 tons grading 69.6% magnetite, 21.9% apatite and 0.173% columbium oxide to 500 foot depth. (Reference: Canadian Mines Handbook, 1966-1967, p. 219). These are the largest known apatite reserves in Ontario.

Geology: Apatite and magnetite replace foliated to massive dark green ijolitic rock in an alkaline-carbonatite complex.

Reference: Parsons (1961, p. 61).

DISTRICT OF KENORA

Big Beaver House Anomaly

Location: Big Beaver House claim group, Misamikwash Lake area, District of Kenora, Patricia portion.

Minerals Present: Apatite, magnetite, calcite, mica, pyroxene, pyrrhotite, chalcopyrite, pyrochlore.

Development: Aeromagnetic anomaly, 9 diamond drill holes totalling 3207 feet drilled in 1962 by Many Lakes Exploration Company Limited.

Geology: An alkaline rock-carbonatite body of round shape three miles in diameter contains concentrations of apatite and magnetite in carbonatite and fenite.

Reference: Aeromagnetic map 939G; Ontario Dept. of Mines, Diamond drill logs, Room 1323, Whitney Block, Parliament Buildings.

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